

A Level Organic Chemistry

A-Level Chemistry ■ Topic 29

A-Level Chemistry



What we will cover

- 1 Naming aromatics
- 2 Two new mechanisms
- 3 The shape of benzene
- 4 Evidence for delocalisation
- 5 Optical isomerism



Two new mechanisms

electrophilic substitution

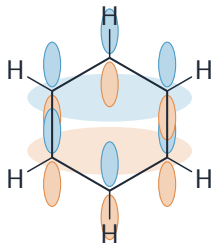
an electrophile re-
places a H on benzene

addition–elimination

a molecule adds on,
then a small one leaves

New families: the **amide** group and **aromatic** compounds (built on a **benzene** ring).

The shape of benzene

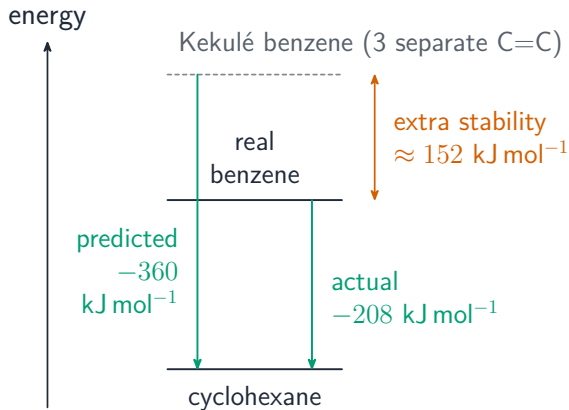


one **delocalised** π system
above and below the ring
 sp^2 σ framework;
all six C–C bonds equal

Each carbon is **sp^2** sp^2 : σ bonds make the flat hexagon, and the leftover p orbitals overlap into one **delocalised** π system.

All six C–C bonds are the **same length**, and benzene is very stable.

Evidence for delocalisation



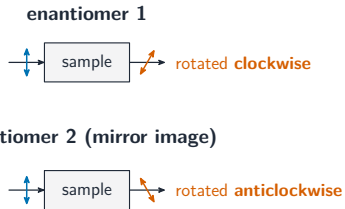
The **enthalpy change of hydrogenation** is the proof:

- Kekulé model predicts -360 kJ mol^{-1}
- real benzene releases only -208

So benzene is $\sim 152 \text{ kJ mol}^{-1}$ **more stable** than the model.



Optical isomerism



a 50:50 **racemic mixture** gives no net rotation (the two cancel)

Two **enantiomers** are identical except:

- they rotate **plane polarised light** in opposite directions (**optically active**)
- a **racemic mixture** (50:50) gives no net rotation

Chirality matters in drugs.

Why chirality matters for a drug

A **chiral centre** is a carbon carrying **four different** groups. Its two **enantiomers** are mirror images – and a living body is not symmetric, so they can have **different biological activity**: one active, the other useless or harmful.

- make both and **separate** them – slow and wasteful
- or use a **chiral catalyst** to make only the one you want

Which of these is chiral?

butan-1-ol – no

butan-2-ol – yes: its C2 carries H, OH, CH₃ and C₂H₅

2-methylpropan-2-ol – no, two methyls are the same

Look for one carbon with four **different** groups. Count carefully – two identical branches kill it.

Why chirality matters for drugs

Two enantiomers

A molecule with a **chiral centre** exists as two enantiomers, and they can behave very differently in the body – one may cure while the other does harm.

Separate them

One route: make the **racemic mixture** and then separate it into the two pure enantiomers – slow, and half the product is wasted.

Or make only one

The better route: a **chiral catalyst** builds just the single enantiomer wanted, so nothing has to be thrown away.

Same formula, same bonds, opposite handedness – and a receptor in the body only fits one of them.

New functional groups at A Level

A **functional group** is the reactive part that names the family and fixes how the molecule behaves. Two join the list:

amide

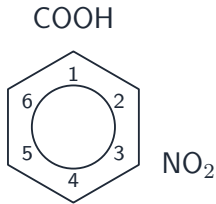
—CONH₂ — a carbonyl bonded straight to nitrogen; the link in proteins and nylon

aromatic

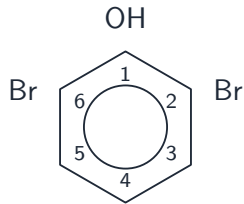
anything built on a benzene ring, with its delocalised electrons and its own chemistry

As before, name the parent chain, then the substituents — and number so the functional group gets the **lowest** locant.

Naming aromatic compounds



3-nitrobenzoic acid



2,4,6-tribromophenol

Number the ring from the principal group (carbon 1); the substituent positions then give the name

Two new types of mechanism

electrophilic substitution

an electrophile replaces an H
on a benzene ring

addition–elimination

a molecule adds on, then
a small molecule is removed

Electrophilic substitution on benzene, and **addition–elimination** at a carbonyl – add, then throw a small molecule out again.

Exam tips

- **Optical isomers** need a **chiral carbon** (four different groups); they are non-superimposable mirror images that rotate plane-polarised light oppositely.
- A **racemic mixture** forms when a **planar intermediate** (carbocation or $C=O$) is attacked equally from both sides.
- Benzene's **delocalised** ring (equal bond lengths, planar) explains its stability versus the Kekulé model.
- Learn the two new mechanisms – electrophilic substitution of arenes, and nucleophilic addition-elimination.



Worked example – spotting a chiral centre

Explain why lactic acid $\text{CH}_3\text{CH}(\text{OH})\text{COOH}$ is optically active but propanoic acid is not.

- Look for one carbon carrying **four different groups**.
- In lactic acid the middle C has CH_3 , OH, COOH and H – all different $\Rightarrow$ a **chiral centre**.
- Its mirror image cannot be superimposed $\Rightarrow$ two **enantiomers**, rotating polarised light oppositely.
- $\text{CH}_3\text{CH}_2\text{COOH}$ has no such carbon (the middle C has two H) $\Rightarrow$ not chiral.

One carbon, **four different groups**. Enantiomers are identical in every physical and chemical property *except* optical rotation and reactions with other chiral molecules.

Topic 29 – key takeaways

1

Mechanisms

electrophilic substitution;
addition–elimination

2

Benzene

sp^2 σ frame + delocalised π ring

3

Delocalisation

more stable than the Kekulé
model

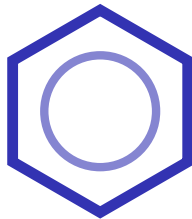
4

Enantiomers

rotate polarised light oppositely

Check yourself

- 1 How does benzene react with an electrophile?
- 2 What hybridisation is each benzene carbon?
- 3 What proves benzene is delocalised?
- 4 What does a racemic mixture do to polarised light?



Answers 1. by electrophilic substitution 2. sp^2 3. its enthalpy of hydrogenation
4. no net rotation